Analysis of a *Goniobasis*-bearing Limestone
from the Colton Formation of Ephraim, Utah.

Senior Thesis

by

Edward M. McEnerney

The Ohio State University

1982

approved by:

James W Collinson

Dept. of Geology and
Mineralogy

Table of Contents

Abstract

During early Eocene time a lake was formed on the flood plain of a river near Ephraim, Utah. This lake was shallow and at least three miles long. It was occupied by clams, crustaceons and snails. These snails became abundant because favorable conditions existed. These conditions were: abundant vegetation, plenty of food, favorable water chemistry and a muddy bottom.

Acknowledgement

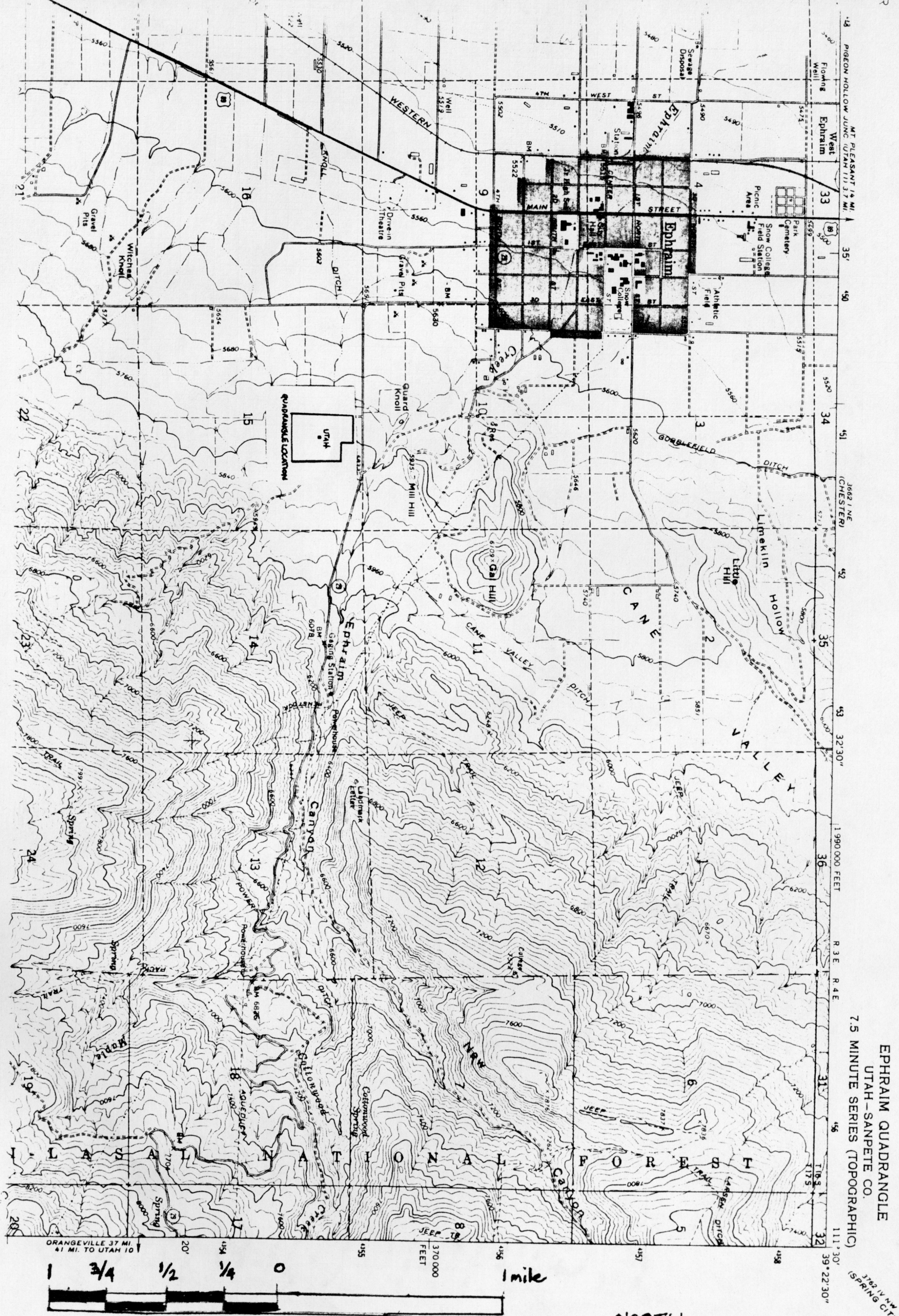
I would like to thank Dr. J.W. Collinson for tolerating my unannounced visits to his office and for the guidance and supervision he provided in the preparation of this paper. I am also indebted to Mort Schmidt for helping me to interpret my thin sections; Jenny Rytel for her generosity in lending me useful references; Phil Stuecheli for comparing field notes with me; and Mrs. Tibbetts for helping me find all of the references I was incapable of finding myself.

Introduction

In June of 1981 while mapping the geology of Ephraim Canyon in Ephraim, Utah, our field party encountered a bed of dark-gray limestone, containing abundant examples of Goniobasis snails with strikingly beautiful calcite fillings. This paper addresses the factors that may have accounted for the existance of such a great number of these snails in this area.

Ephraim Canyon Description

The limestone bed occurs in NE $\frac{1}{4}$, NE $\frac{1}{4}$, S14, T 17 S, R 3 E of the Ephraim 7.5 minute quadrangle. This area is located on the western flank of the Wasatch Plateau, which is a gently west dipping monocline that terminates against the San Pete Valley. The western flank of the plateau is basically a dip-slope that trends approximately NE 30° and dips approximately 30° NW. In Ephraim Canyon the Flagstaff and Colton formations are exposed. Although older, the Flagstaff Formation is located at higher elevations than the Colton on this slope because the slope dips slightly less than the beds. There is a series of antithetic faults that strike nearly due north and cut the Flagstaff. There has also been rockslides in the area which have covered some of the Flagstaff and Colton.



from: U.S. Dept. of Interior : Geological Survey

Limestone Field Description

The limestone which is the subject of this report was found near the base of the Colton Formation. It is a gray to gray-black, fine-grained, massive limestone, showing sparry calcite filling of gastropod fossils. Samples were collected from the outcrop and also from nearby stream valleys which have transported much of the limestone downslope to the valley floor. The transported samples differ from the outcrop samples in that they are generally weathered to a very light-gray color and are also brittle enough, in many cases, to be broken by hand. This outcrop of limestone is approximately 1.0 ft thick. It strikes NE 30° and dips 30-40° NW. It is interbedded with sandstone and mudstone.

Flagstaff Formation

It is important to understand some of the history of the Flagstaff Formation in order to get a better understanding of the Colton Formation history. Spieker (1946) describes the Flagstaff as Paleocene in age, and consisting dominantly of fresh water limestone with interbedded gray shale and minor amounts of sandstone, gypsum, oil shale and volcanic ash. He describes the outcrops as white or cream colored, varying in thickness from 200 to 1000 ft. Wells (1977, p.119) describes the depositional environment as a large shallow calcareous alkaline lake surrounded by mudflats.

Stanley and Collinson (1979) suggested that the lake basin represents the final phase of subsidence and infilling of a foreland basin east of the Sevier thrust belt.

The Flagstaff can be divided into three sections representing three distinct phases of the lake (Wells,1977). The lower member was a very productive, abundantly vegetated lake containing many fresh water mollusks (including Goniobasis). The middle member was restricted and more saline, because of a lowering of the lake level, probably caused by an increase in the aridity of the climate (Stanley and Collinson, 1979). During this phase of the lake playa-like conditions existed, so therefore the vegetation and mollusks disappeared (Wells, 1977). The upper member of the Flagstaff appears to represent a period quite similar to that of the lower member in that there was abundant vegetation and a reappearance of Goniobasis. Wells (1977) described the lake floor as being soft and muddy, and the water as being turbid. Marcantel and Weiss (1968) theorized that prehistoric Lake Flagstaff was surrounded by a land surface of low relief, because of a lack of much clastic sediments found within the formation. The history of Lake Flagstaff doesn't end in total extinction, but is gradually filled by sediments by the invasion of Colton sediments and the merging of the northern part of the basin with the Green River Lake (LaRocque, 1960).

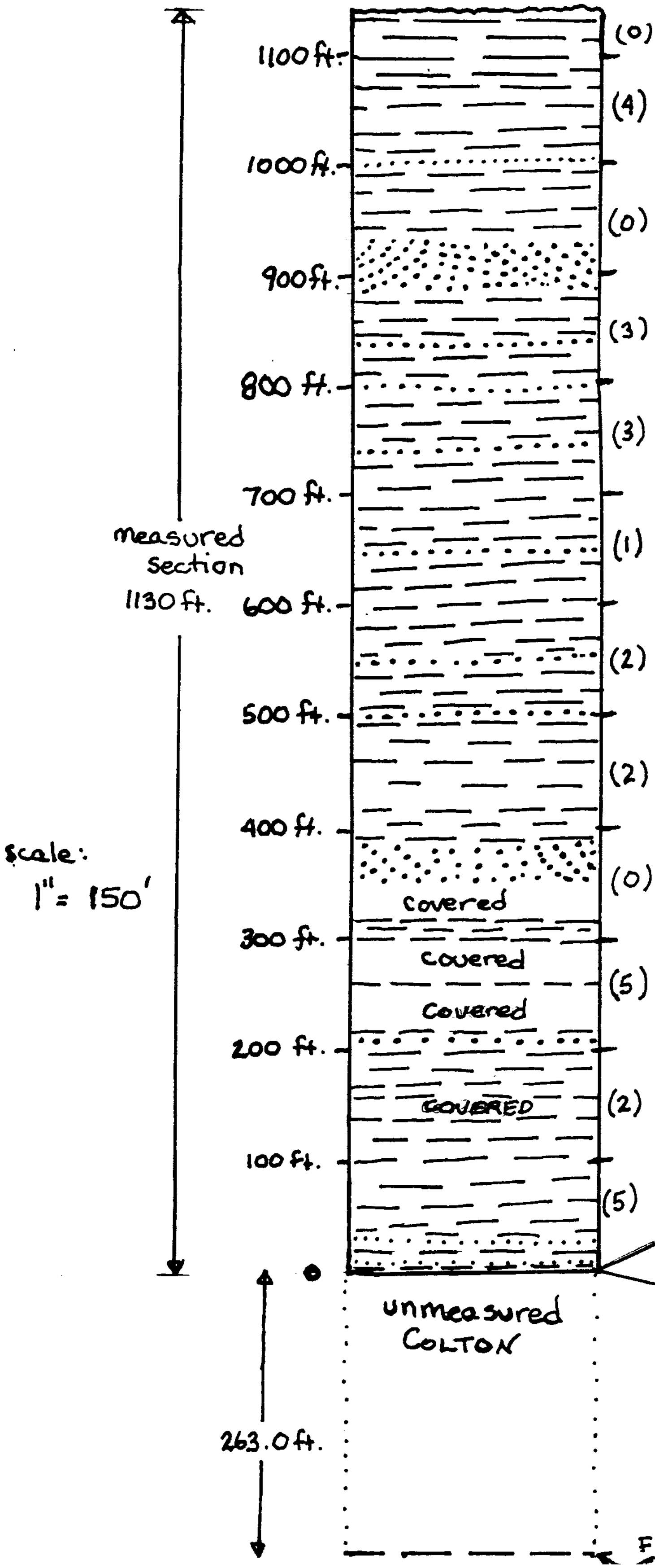
Colton Formation

Spieker (1946) describes the Colton Formation as " gray, pepper and salt sandstone, greenish-buff sandstone, and siltstone that commonly weathers golden brown, and shale ranging in color from deep red to variegated and gray in color". He classifies the age of the Colton as Wasatch (or early Eocene). Bonar (1948) considers the Colton strata to be dominantly of flood plain and channel origin, with local lake conditions resulting in the deposition of scattered limestone beds. He used this particular Goniobasis-bearing limestone bed in order to correlate Ephraim Canyon with Pigeon Creek:

"A dark blue-gray limestone containing an abundance of Goniobasis showing colorless calcite replacement was used as a basis of correlation between the Pigeon Creek and Ephraim Canyon sections. This bed is unique in that there is none other like it in the entire section and it is an excellent unit for use in correlation as the possibility for error is at a minimum". The distance from Ephraim Canyon to Pigeon Creek is approximately three miles so it can be assumed that this lake was at least three miles long.

The fact that the Colton Formation is of flood plain origin and channel origin is supported by analysis of the measured section (see next page). This section represents the Colton Formation exposure in Ephraim Canyon. Its total thickness here is about 1130 ft. Generally the section is composed of alternating layers of mudstones, sandstones and occassional limestones. The mudstones are indicative of the flood plain environment, being deposited by rivers during flood stage. The channel sandstones, which have cross bedding

Stratigraphic Section of COLTON Formation in Ephraim Canyon.



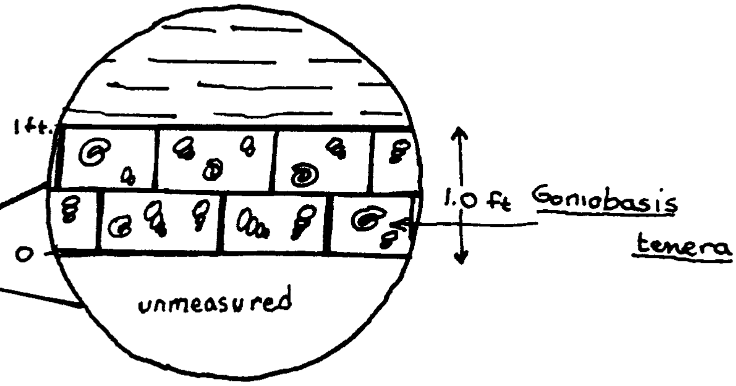
Key:

Mudstone: Red, brown, gree and gray, nonfissile mudstone: of flood plain origin.

Channel Sandstone: Red to brow coarse grained sandstones with cross bedding and scour marks.

Limestone: generally whi to buff colored, fine-grained, fossiliferrous.

(#) : indicates the number of limestones found within a particular one-hundred foot interval (these are too thin to be seen at given scale)



Magnified (100x) Section 1" = 1.5'

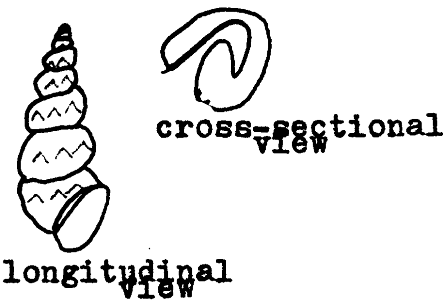
and scour marks are obvious indications of former river beds. The limestone beds are generally less than 1.0 feet thick and located between various mudstone outcrops. These facts would seem to indicate that the limestones were formed in small lakes or ponds on the flood plains, and were eventually covered by more flood plain deposits.

Colton-Flagstaff Boundary

The Colton-Flagstaff contact in Ephraim Canyon is a gradational one. Here the clastic sediments of the Colton interfinger with the limestones of the Flagstaff. Because there is no clear-cut contact, generalities are used to approximate a boundary. Marcantel and Weiss (1968) suggested defining the contact by four general criteria: 1) the clastic nature of the rocks increases significantly and persists 2) the fossil content of the rocks shows a marked and persistant decrease 3) the abundance of carbonate rocks decrease strikingly 4) the prevailing color of the rocks changes from brown or gray to red, green or pastel colors.

Goniobasis tenera

Snail fossils identified as Goniobasis tenera dominate this limestone. It is technically described by La Rocque (1960) as having a "dextral, elongate shell, which is turreted to ovate conic, with many whorls; axially plicate, spirally striate". In less complicated terms this means that this snail is elongated about an axis, and has several interconnected chamber whorls which taper towards the end. It is a gill-breather, which generally requires a well-oxygenated fresh water environment, with plenty of micro-organisms to eat (La Rocque, 1956, p.143). In North America today the genus is very widespread. They are found most abundantly in the southeastern United States. In general there is a greater number of species south of the Ohio River and east of the Mississippi River (La Rocque, 1960).



<u>GONIOBASIS</u>

According to Henderson (1935) the species *Goniobasis tenera* is found in Eocene formations located in Wyoming, Colorado, Utah and New Mexico. La Rocque (1960) suggested that a favored environment of *Goniobasis* might be a soft, muddy bottom with turbid water and plenty of vegetation.

In the Flagstaff and Colton formations *Goniobasis tenera* occurs at three distinctive horizons, in the lower and upper sections of the Flagstaff (Wells, 1978) and also in the Colton. It seems likely that the snails migrated with the lakes and became abundant when the conditions became most favorable. "Gill-breathing gastropods are slow to invade new territory for their eggs are either attached to the bottom or hatched within the body of the parent. Some of them may be carried to new environments on the shells of turtles, others by following rivers and brooks connecting a chain of lakes" (La Rocque, 1956, p.144).

Thin Section Analysis

Thin section analysis of this limestone reveals a matrix composed almost entirely of grain-supported peloids. A peloid is a grain that is constructed of an aggregate of cryptocrystalline carbonate, regardless of origin (McKee and Gutschick, 1969). These peloids vary in size, but average about .05 millimeters. They are generally spherical to elliptical and show no internal structure. There are several structures present in which these peloids occur in clusters (see Figure #2), it is not certain as to the origin of these structures, but they may be related to the micritization of algae.

A few types of fossil fragments occur in these sections. Fragments of arthropods, showing wavy extinction (probably from fresh water crustaceons) are present, but not abundant. Also present are pelecypod fragments, but these too are not abundant. In addition many unidentifiable fragments were broken during river transport or by predators such as crustaceons.

The dominant fossil present in these thin sections is Goniobasis tenera. In these slides (cut perpendicular to the bedding) these snails are seen longitudinally, cross-sectionally and obliquely. The shell from these organisms is still intact, indicating that the original shell material was probably calcite, otherwise an aragonitic shell would

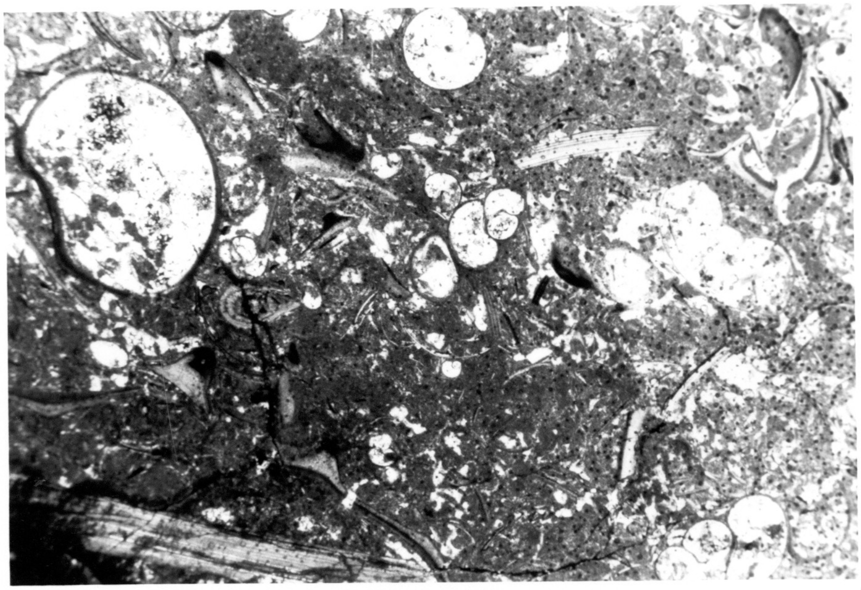


Figure #1: showing sparry calcite filling of gastropod chambers; pelycypod fragment (lower left corner); assorted fossil fragments; and fine-grained pelloidal matrix.
(area shown is 8m.m. x 13.6 m.m.)

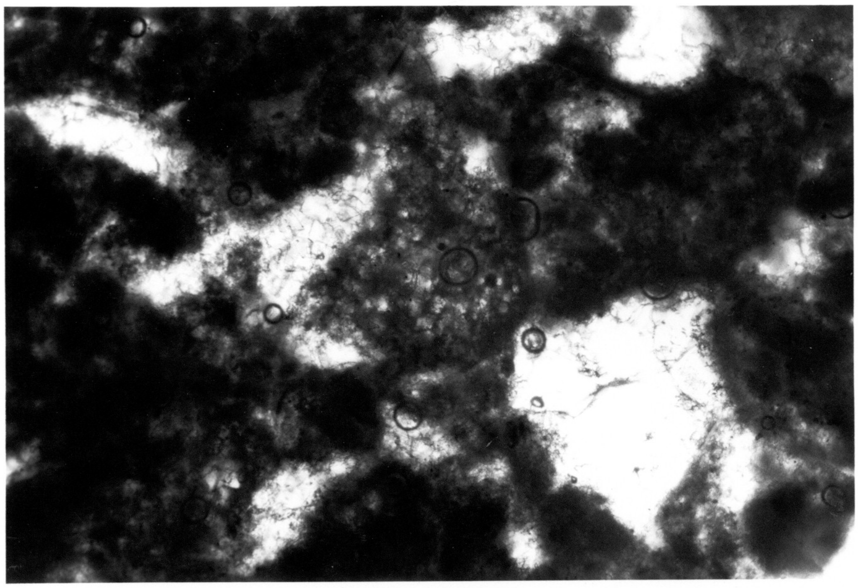


Figure #2: showing a cluster of peloids, this structure may have formed during the micritization of algae.

(area shown is 3.4 m.m. x 2.0 m.m.)

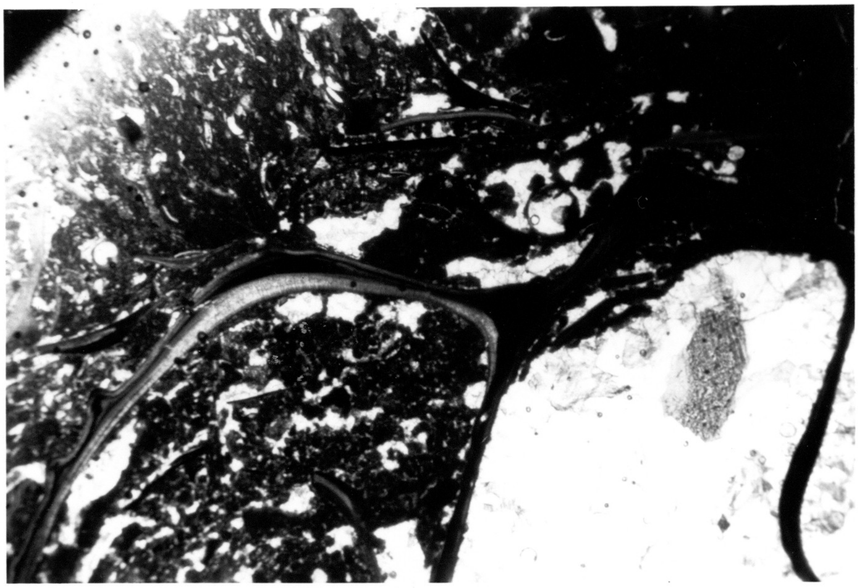


Figure #3: showing the intact shell of the original snail; the chamber to the left was the outer chamber and it became filled with mud, the chamber to the right had sparry calcite precipitated into it.

(area shown is 3.4 m.m. x 2.0 m.m.)

have been recrystallized due to mineral instability. The once hollow chambers of these snails have been filled with mozaics of calcite spar. Folk (1964) describes this as a "passive precipitation process". In general this cavity filling calcite is tightly interlocking and the grains are all roughly the same size. Bathurst (1971, p.494) lists three ways of recognizing cavity filling spar: 1) a regular distribution of crystal size 2) plenty of plane intercrystalline boundaries 3) high percentage of enfacial junctions among the triple junctions of the grains. These criteria seem to be present in the thin sections, so there is little doubt as to the origin of this sparry calcite.

Conclusion

Several possible reasons can be offered for the great abundance of snails that lived in this Colton lake environment, all of which appear to be related to climate. During the first and third phase of Lake Flagstaff, Goniobasis were abundant. During the second phase the water became saline due to an increased aridity of the climate and as a result organisms became scarce. It seems reasonable to conclude then that the chemistry of this Colton lake was roughly similar to that of the favorable Flagstaff environment. This tells us that the climate during this time was at least wet enough so that the lake water wasn't evaporated at a higher rate than water was added by rainfall and runoff. This favorable water chemistry also allowed plant life to thrive in Lake Flagstaff. Presence of abundant plant life in this Colton lake environment was speculated upon earlier in the thin section analysis, additional evidence for the presence of plant life is the black color of the outcrop in places. This lake also had to be full of micro-organisms in order to feed such a dence population of snails. The favored environment of a soft, muddy bottom was also obtained, this is shown by thin section analysis.

It also may be possible to conclude that this Colton lake environment was very much similar to that of the southeastern United States today, although there may not have been quite as much precipitation. There were turtles, fish, (Bonar, 1948) reptiles and water birds (Stanley and Collinson, 1979) present, indicating a relatively warm climate. Also the fact that Goniobasis are found most commonly in the southeastern states today, lends additional support to this theory.

References

1) Bathurst, R.G.C., 1971, Carbonate Sediments and Their Diagenesis; Elsevier Publishing Co., 620p.

2) Bonar, C.M., 1948, Geology of Ephraim Area, Utah; Ohio State University Masters Thesis, 124p.

3) Folk,R.L., 1964, Some Aspects of Recrystallization in Ancient Limestones; Society of Economic Paleontologists and Mineralogists; Spec. Pub. #13 (1965) p.14 -48

4) Henderson, J., 1935, Fossil Non-Marine Mollusks of North America; Geological Society of America, Special Paper #3, 291p.

5) La Rocque, A., 1956, Tertiary Mollusks of Central Utah; International Association of Petroleum Geologists, vol. #7 (1956) p. 143-144

6) La Rocque, A., 1960, Molluscan Faunas of the Flagstaff Formation of Central Utah; Geological Society of America Memoir #78, 100p.

7) Marcantel, E.L., and Weiss, M.P., 1968, Colton Formation and Associated Lacustrine Beds, Gunnison Plateau, central Utah; Ohio Journal of Science v. 68/1, p. 40-49

8) McKee, E.D. and Gutschick, R.C., 1969, History of Redwall Limestone of Northern Arizona; Geological Society of America Memoir 114, p.101

9) Spieker, E.M., 1946, Late Mesozoic and Early Cenozoic History of Central Utah; U.S. Geological Survey Prof. Paper 205D

10) Stanley, K.O. and Collinson, J.W., 1979, Depositional History of Paleocene-Lower Eocene Flagstaff Limestone and Coeval Rocks, Central Utah; American Association of Petroleum Geologists Bulletin v. 63/3 p.311-323

11) Wells, N.A., 1977, Paleocene-Eocene Lake Flagstaff of Central Utah; Ohio State University Masters Thesis 175p.